FRDA REPORT 141

DEVELOPMENT OF PLANTING TOOL FOR LONG-ROOTED SEEDLINGS TO OPTIMIZE INVERTED HUMUS MOUND PERFORMANCE

by
R.G. McMinn

Contractor: Loentech Engineering Ltd.
Box 557
Armstrong, B.C.

Prepared by:
Kindwood Research Ltd.
499 Millstream Lake Road
RR 6
Victoria, B.C. V8X 3X2

Departmental Representative:

Wayne Coombs
Pacific Forestry Centre
Forestry Canada
506 West Burnside Road
Victoria, B.C. V8Z 1M5

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Abstract

The establishment at 38 km on the Beaver Road, east of Prince George, of a test site to compare the relative effectiveness of long-rooted interior spruce seedlings (PSB 323) planted in mineral soil capped inverted humus mounds is described. The long-rooted seedlings were larger and had more new roots than standard sized seedlings at the end of the first full growing season. The prototype planting tool developed to plant long-rooted seedlings was found to be very effective even when mounds with deep mineral soil cappings were dry.

Acknowledgements

The donation of seedlings to this project by Pelton Reforestation Ltd. is gratefully acknowledged. The B.C. Ministry of Forests supplied the seed. Beaver Plastics Ltd, Edmonton, Alberta donated the PSB 323 styrofoam moulds in which the long-rooted seedlings were grown. Also ackowledged with thanks is the measurement of seedling physical parameters and RGC determinations by B. Hooge and staff of the Red Rock Research Centre. Gratitude is expressed to Mr. Bas Rynsewyn, Mr. Doug Bryce and the many others who cleared the demonstration area and constructed the mounds. Mr. Bryce also assisted in the planting and tagging of seedlings. Mr. M. Grismer and Mr. M. Leask assisted with the measurement of seedlings.

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Introduction

Inverted humus mound planting spots (inverted LFH layers covered by mineral soil) can provide favorable growing conditions for interior spruce seedlings. The capping acts as a heat sink, providing a warm growing medium for the roots of planted seedlings. Competing vegetation is controlled when cappings are deep enough. The H layer, which is uppermost after inversion and next to the underside of the mineral soil cap, provides a source of nitrogen for seedlings rooted in this warm, friable layer. Mounds are favorable on subhygric and hygric sites because seedling roots are better aerated than in planting spots level with or lower than the general ground level.

However, in climates with significant dry periods, seedlings may suffer moisture stress unless their roots are in contact with moist soil beneath the mound. Susceptability to moisture stress is especially pronounced when the mineral soil capping is deep. However, moisture may accumulate beneath mounds when vegetation is controlled because transpiration by vegetation is the main way in which moisture is reduced in the soil beneath mounds. Seedlings with normal root lengths (eg 13 cm for PSB 313) must be planted partly buried if their roots are to contact the supply of moisture at the base of mounds. The need to plant deeply is accentuated when the capping depth of mounds is deep. Deep capping may be needed when competing vegetation is likely to be aggressive.

An alternative to deep planting is the use of long-rooted seedlings having roots which reach down to the moisture beneath mounds without requiring planting deeper than the root collar. PSB 323 seedlings, which have 23 cm long root systems, can be planted in such a manner. Planting long-rooted seedlings through two layers of LFH (the inverted layer above the *in situ* layer) is difficult. Planted incorrectly, seedlings may be J-rooted, with their root systems in the mineral soil capping. In that configuration, PSB 323 seedlings are as vulnerable to drought as standard root-length seedlings planted to the root collar. A prototype planting tool has been developed to make deep planting easy. This new tool was field tested in August 1988 to plant a trial which is serving to test the effectiveness of long-rooted (PSB 323) seedlings in mounds. Two capping depths are being tested.

This report provides information on the establishment of the trial and the results by the end of the first growing season. The trial was established near 38 km on the Beaver Forest Road, east of Prince George (Fig. 1) in the SBSj1. The test area is adjacent to the site of FRDA Project 1.01 (E.P. 971.03) (Draper and Herring 1986). The whole site is protected by a map reserve (Fig. 2). FRDA Project 1.01 is a major benchmark trial in northern British Columbia. The location of this Federal Direct Delivery Project nearby should increase the number of visitors viewing the Federal Project and enhance viability of the site as a demonstration destination.

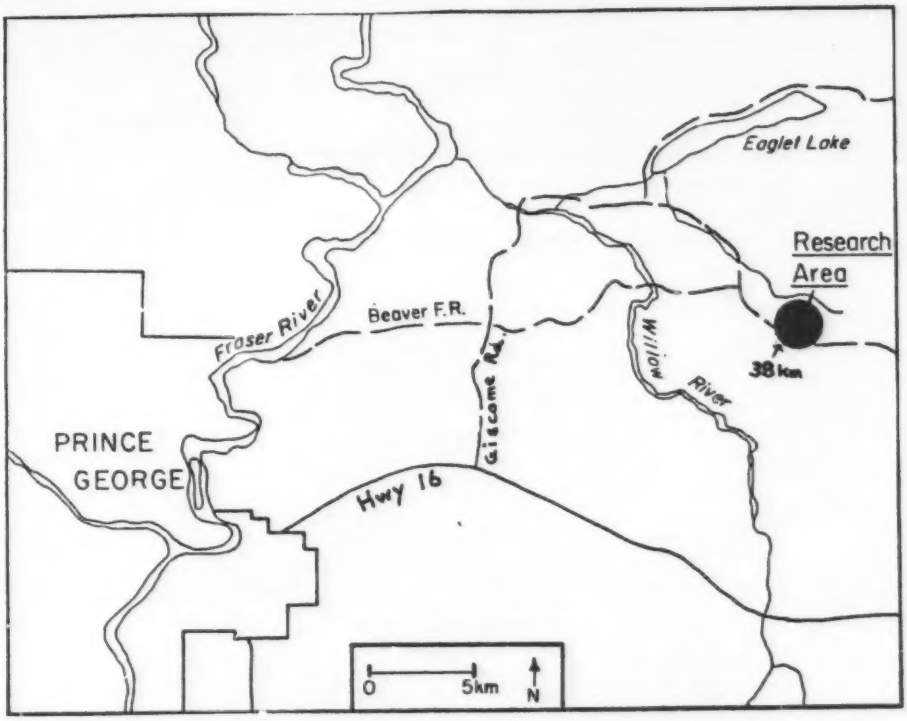

Fig. 1. Location of Beaver Road Research Area at 38 km on the Beaver Forest Road, east of Prince George.

Objectives

1. Development of a planting tool which will consistently plant long-rooted seedlings to a depth of at least 23 cm thereby reaching the soil beneath inverted humus mounds.
2. Test the effectiveness of long-rooted seedlings planted with their root systems reaching beneath the humus layer of inverted humus mounds.

This report describes the establishment of a test area to compare the relative effectiveness of PSB 313 and PSB 323 interior spruce seedlings in mineral soil capped inverted humus mounds. The effectiveness of the new planting tool is also reported.

Province of British Columbia
Ministry of Forests

MAP OF ▸ 920-2-1-3-241

EXHIBIT 'A'

	Zone	East	North	Reg	Compt	L
U.T.M						
Grid	10	546000	5985000	59	101	

Date October 28/87.
Ref. Map 93J-SE(a-5)
Base 93J-1-b,c
Scale 1 : As shown Below
Area 100 hectares ±

F. D. - 2
R. D. - 8

FOREST REGION ▸ Prince George
LAND DISTRICT ▸ Cariboo
DISTRICT ▸ Pr. George East
OUTLINE ▸

MANAGEMENT UNIT		TIMBER SUPPLY AREA		PULPWOOD AGREEMENT	CASCADES	
Type	I	Number	22			
Number	90	Block			East	X
Block		Sub-B			West	

- WILLOW RIVER FOREST -

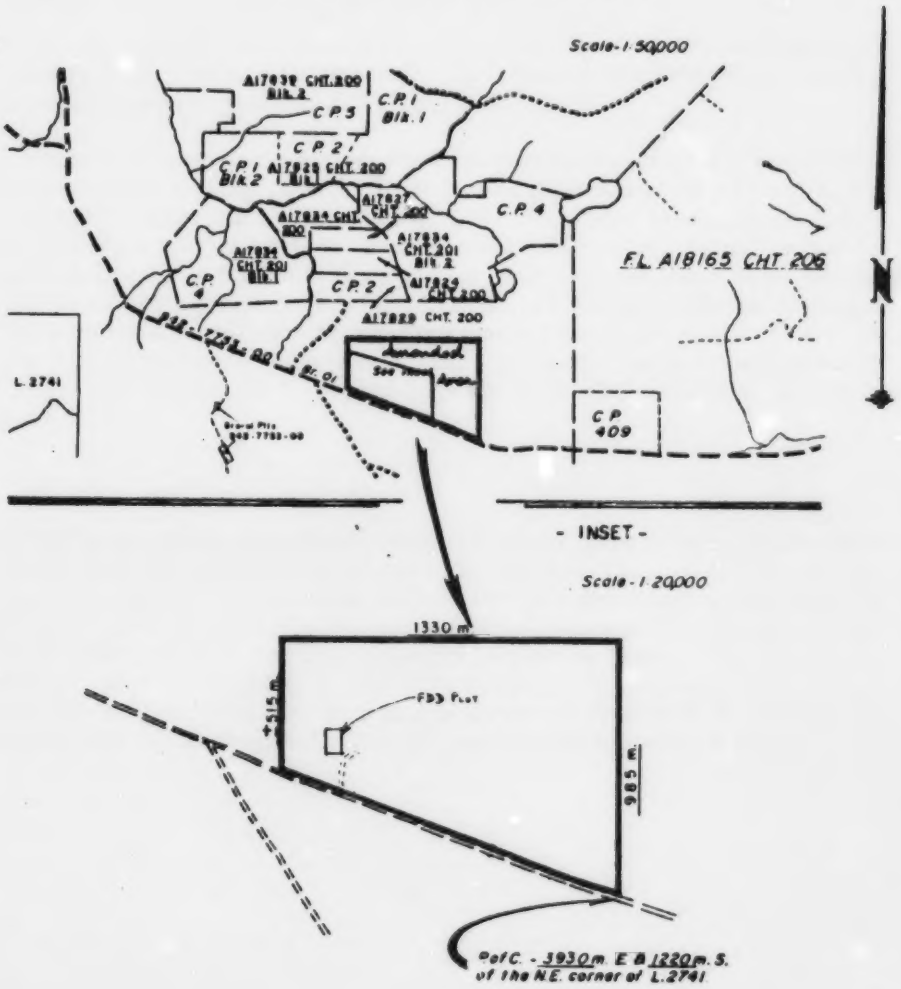

Fig. 2. Map Reserve covering the Beaver Road Research Area at 38 km on the Beaver Forest Road, east of Prince George.

Methods

Site Selection

The site selected is on the nearly level terrain of a post–glacial lake deposit, typical of the Nechako Plain landform (Holland 1976). Soil textures range from clay loam to very fine sandy loam indicating that the soils are a mosaic of Aleza Lake clay loams and Bowron very fine sandy to silty loams (Hortie et al 1970). The undulating topography, coupled with the variation in soil texture, means that moisture regime varies from mesic to subhygric. Association names have not yet been assigned to these sites. The area is wet in spring but dries appreciably by midsummer.

Site Preparation

Trees on the site were hand felled and cleared by carrying all trunks and branches outside the 2/3 ha test area during the first week of October 1987. This procedure simulated winter shearing which, when properly executed, leaves the LFH layers essentially intact.

Hand construction of inverted humus mounds was completed by mid October 1987. Nominal depths of the mineral soil cappings (ie depth at the time of construction) were 12 and 20 cm. Overwinter settling generally reduces capping depth (Hedin 1988). Mounds were constructed by overturning a 40 x 40 cm "pad" of LFH and covering it with a dome of mineral soil so that the pad was completely covered. A frame 40 x 40 cm by 12 or 20 cm deep was placed on the pad and filled with mineral soil from the adjacent area from which the LFH had been removed. Shoulders of mineral soil were added so that after the frame was removed the mound was still 40 x 40 cm (1600 cm^2) on top. The volume of mounds with 12 and 20 cm of cappings was approximately 30 and 60 l respectively. Mounds are 2.5 m apart in groups of 24. The layout of the mounds is shown in Figure 3.

Stock

PSB 313 and PSB 323 interior spruce seedlings (Seedlot 8617) were raised at Pelton Reforestation Ltd., Maple Ridge, B.C. The seed was sown in March 1987 and the stock raised as 2+0 seedlings. Additional seed from seedlot 4144 was sown in June 1987 and also raised as 2+0 PSB 323 seedlings. All stock was lifted on 29 July 1988 and transported overnight for temporary storage in a cooler at Red Rock Nursery. Seedling parameters are given in Table 1. The March sown PSB 323 seedlings, which are designated as PSB 323M in this report, were larger than average. The June sown PSB 323 stock (PSB 323J) were used to test the effectiveness of the planting tool with average sized PSB 323 seedlings and to test their performance following planting.

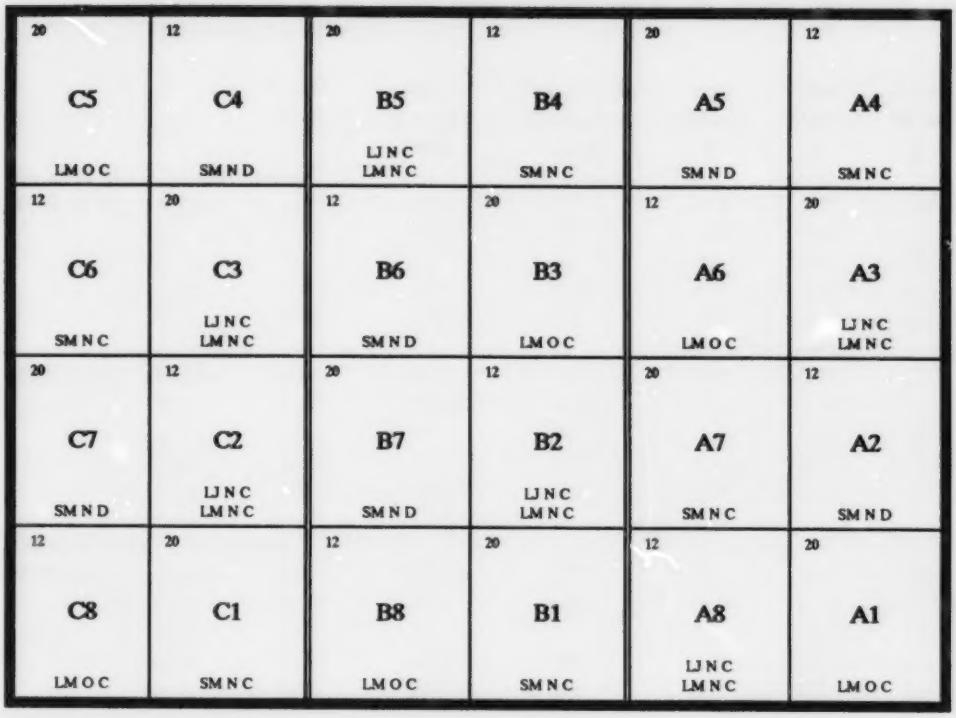

Fig. 3. Plot layout at the Beaver Road Research Area at 38 km on the Beaver Forest Road, east of Prince George.

Capping depth: 12 = 12 cm deep mineral soil capping;
20 = 20 cm deep mineral soil capping;
Stock: LM = PSB 323 (Mar)
LJ = PSB 323 (June)
SM = PSB 313 (Mar)
Planting tool: O = shovel;
N = new tool
Planting depth: C = control (to root collar).
D = deep.

Table 1. Root Growth Capacity (R.G.C.) and physical parameters of PSB 313 and PSB 323 stock planted at the Beaver Road Demonstration Site to test the effectiveness of long-rooted seedlings.

		R.G.C. Class	Shoot Length mm	Root Collar Diameter mm	Stem Mass g	Root Mass g	Total Mass g
Seedlot 8617 (March Sown)							
PSB 313M	Mean	2.3	357	4.7	4.5	1.3	5.8
	SD	1.20	49.6	0.77	1.17	0.54	
	n	16	30	30	30	30	30
	Max	4.0	467	6.5	6.9	2.6	9.5
	Min	1.0	232	3.3	2.7	0.6	3.3
PSB 323M	Mean	2.6	602	4.7	9.5	2.7	12.2
	SD	1.26	103.6	0.74	3.34	1.16	
	n	16	30	30	30	30	30
	Max	4.0	838	6.0	17.1	6.1	23.2
	Min	1.0	366	2.4	2.9	0.8	3.7
Seedlot 4144 (June Sown)							
PSB 323J	Mean	1.8	356	2.7	2.6	0.8	3.4
	SD	0.98	47.4	0.42	0.69	0.31	
	n	16	15	15	15	15	15
	Max	3.0	436	4.0	4.5	1.6	6.1
	Min	0.0	261	2.1	1.3	0.3	1.6

Parameters Tested and Plot Layout

The following parameters are being tested:

Stock type: March sown PSB 313, Seedlot 8617 (PSB 313M).
March sown PSB 323, Seedlot 8617 (PSB 323M).
June sown PSB 323, Seedlot 4144 (PSB 323J).

Mound depth: 12 cm mineral soil capping above inverted surface organic matter.
20 cm mineral soil capping above inverted surface organic matter.

Planting tool: New tool (N).
Old tool (planting shovel) (O).

Planting depth: Control (to root collar).
Deep (5 cm below root collar).

Twenty-four seedlings were planted per Plot. Each Plot was replicated 3 times (Blocks A, B, C) (Fig. 3). The PSB 323J seedlings were double planted on 12 and 20 cm capped mounds also planted with PSB 323M stock. Seedlings were planted on 1 and 2 August 1988 using either the new planting tool or a planting shovel. Depth of planting was normal (control) or deep. Normal planted seedlings had their root collars at soil level. Deep planted seedlings had their root collars buried 5 cm so that some of the foliage was buried. Seedlings were identified with round, blue, numbered, plastic tags attached to spring-steel markers. Markers were color coded with flagging tape for each treatment type:

Color	Treatment	
Red/candy orange:	20cm mound, PSB 323M, new tool, control	[20-LMNC]
Red/yellow:	20cm mound, PSB 323M, shovel, control	[20-LMOC]
Red/candy blue:	20cm mound, PSB 323J, new tool, control	[20-LJNC]
Red/white:	20cm mound, PSB 313J, new tool, control	[20-SMNC]
Red/orange:	20cm mound, PSB 313J, new tool, deep,	[20-SMND]
Blue/candy orange:	12cm mound, PSB 323M, new tool, control	[12-LMNC]
Blue/yellow:	12cm mound, PSB 323M, shovel, control	[12-LMOC]
Blue/candy blue:	12cm mound, PSB 323J, new tool, control	[12-LJNC]
Blue/white:	12cm mound, PSB 313J, new tool, control	[12-SMNC]
Blue/orange:	12cm mound, PSB 313J, new tool, deep	[12-SMND]

Plot, mound size, treatment, tag number and the number of seedlings planted are given in Table 2.

Seedling and Vegetation Assessment

The survival and condition of seedlings was monitored on 17 September 1988, six weeks after planting.

The survival, total height, leader increment, diameter and condition of seedlings were recorded on 3 September 1989 after one full growing season. Stem volume was calculated as 1/3 basal area times seedling height. Samples to determine the amount of root growth were collected 17 and 20 October 1989. The washed, oven-dry weight of tops and roots were determined. New roots, developed during the 1989 growing season were separated from the plug, cut off and weighed separately from the remainder of the plug. Data were analysed by the Duncan's Multiple Range Test.

The ingrowth of vegetation after clearing the site (ie the vegetation growing in untreated areas between the mounds) and the invasion of mounds were assessed on 14 July 1989. Seedling-centred, circular plots 50 cm in diameter (2000 cm^2) were used for the assessment. The parameters recorded were average height of vegetation and the percentage of the circle covered.

Table 2. Plot number, mound size, treatment, tag number and number of seedlings planted at Beaver Road Demonstration Site.

Plot number	Mound[1] size	Treatment[2] Sdl	Tool	Depth	Tag #	# planted
A1	20	LM	O	C	4201-4224	24
A2	12	SM	N	D	4225-4248	24
A3	20	LJ	N	C	4249-4272	24
A3	20	LM	N	C	4801-4820	20
A4	12	SM	N	C	4273-4296	24
A5	20	SM	N	D	4297-4320	24
A6	12	LM	O	C	4321-4344	24
A7	20	SM	N	C	4345-4368	24
A8	12	LJ	N	C	4369-4392	24
A8	12	LM	N	C	4781-4800	20
B1	20	SM	N	C	4393-4416	24
B2	12	LJ	N	C	4417-4440	24
B2	12	LM	N	C	4821-4840	20
B3	20	LM	O	C	4441-4464	24
B4	12	SM	N	C	4465-4488	24
B5	20	LJ	N	C	4489-4512	24
B5	20	LM	N	C	4841-4860	20
B6	12	SM	N	D	4513-4536	24
B7	20	SM	N	D	4537-4560	24
B8	12	LM	O	C	4561-4584	24
C1	20	SM	N	C	4585-4608	24
C2	12	LJ	N	C	4609-4632	24
C2	12	LM	N	C	4874-4886	13
C3	20	LJ	N	C	4633-4656	24
C3	20	LM	N	C	4861-4873	13
C4	12	SM	N	D	4657-4680	24
C5	20	LM	O	C	4681-4704	24
C6	12	SM	N	C	4705-4728	24
C7	20	SM	N	D	4729-4752	24
C8	12	LM	O	C	4753-4776	24
						682

[1]**Mound size:** 20 = 20 cm deep mineral soil capping.
12 = 12 cm deep mineral soil capping.

[2]**Treatment:** Seedling type: LM = 2+0 PSB 323 (March sown).
LJ = 2+0 PSB 323 (June sown).
SM = 2+0 PSB 313 (March sown).

Tool: N = New planting tool.
O = Old planting tool (planting shovel).

Depth: C = Control depth (planted to ± 1 cm below root collar).
D = Planted deeply (5 cm below root collar).

Results

Seedling Survival

The survival of all stocks (PSB 323M, PSB 323J, PSB 313) was high under all the conditions (type of planting tool, size of mound, depth of planting) being tested (Tables 3 and 4).

The tally of seedling survival made 17 September 1988, 6 weeks after planting showed that all seedlings were alive (Table 3). The top of two seedlings had been nipped off by hares and two seedlings had been pressed down by a moose walking on them. These latter seedlings were raised again and subsequent observations indicated that there had been no noticeable effect.

Table 3. Condition of seedlings when monitored on 17 September 1988 at the Beaver Road Site.

Treatment				Condition					
				Lower foliage					
Stock[1] Type	Mound[2] size	Plant[3] tool	Depth[4] plant	Gn/droop[5]	Brown	Red	Dead bud	Moose tread	Hare clip
323M	12	old	ctrl	1	3	-	-	-	-
323M	20	old	ctrl	6	3	4	-	1	-
323M	12	new	ctrl	2	-	2	1	1	-
323M	20	new	ctrl	4	1	11	-	-	-
323J	12	new	ctrl	-	-	-	-	-	2
323J	20	new	ctrl	1	-	-	-	-	-
313M	12	new	ctrl	6	12	4	-	1	-
313M	20	new	ctrl	3	5	3	-	-	-
313M	12	new	deep	1	-	-	-	-	-
313M	20	new	deep	2	5	1	-	-	-

[1]**Stock type:** PSB 323M (March sown); PSB 323J (June sown); PSB 313M (March sown).
[2]**Mound size:** 12 or 20 cm mineral soil cap over inverted humus.
[3]**Planting tool:** old = shovel; new = new tool.
[4]**Planting depth:** ctrl = control (planted to root collar);
deep = planted with root collar 5 cm below soil line.
[5]**Gn/droop** = needles green but drooping.

Four levels of stress, probably related to moisture deficits, were evident in September 1988. The needles on the lower shoots of affected seedlings could be differentiated as:

1. green, but drooping;
2. brown and drooping;
3. red;
4. terminal bud damage.

Table 3 shows the frequency of symptoms among the various treatments in September 1988. Lateral buds on the seedling with a dead terminal bud appeared to be healthy so that one of them became the 1989 leader. The tag number of apparently stressed trees is given in the Appendix so that the future development of individual seedlings which showed stress symptoms can be monitored.

The majority of foliage symptoms occurred in the PSB 323M seedlings planted in 20 cm mineral capped mounds and in the PSB 313M seedlings planted at the standard depth (to the root collar) in both mound capping depths (Table 3). The PSB 323J seedlings, the PSB 313M seedlings planted deeply and the PSB 323M seedlings planted in 12 cm mineral capped mounds had considerably fewer foliage symptoms.

The terminal buds of many seedlings in all three stock types failed to elongate in the spring of 1989. Many leaders, consequently, were formed from lateral buds (Table 4). Survival of all seedlings was high, nevertheless. The number of leaders which had been clipped by hares had increased considerably by the fall of 1989. Clipping frequency, however, seemed more related to location on the site than to stock or treatment. Frost heaving had affected only a small number (5) of seedlings.

Table 4. Condition of seedlings when monitored on 3 September 1989 at the Beaver Road Site.

Treatment				Condition			
Stock[1] type	Mound[2] size	Plant[3] tool	Depth[4] plant	Survival %	Leader from lateral bud %	Clipped by hare %	Frost heaved %
323M	12	old	ctrl	100	22	-	1
323M	20	old	ctrl	99	18	4	-
323M	12	new	ctrl	100	17	4	-
323M	20	new	ctrl	100	26	9	-
323J	12	new	ctrl	96	32	1	1
323J	20	new	ctrl	100	26	25	1
313M	12	new	ctrl	93	40	15	-
313M	20	new	ctrl	93	37	-	-
313M	12	new	deep	97	34	9	-
313M	20	new	deep	100	40	27	1

[1]Stock type: PSB 323M (March sown); PSB 323J (June sown); PSB 313M (March sown).
[2]Mound size: 12 or 20 cm of mineral soil capping over inverted humus.
[3]Planting tool: old = shovel; new = new tool.
[4]Planting depth: ctrl = control (planted to root collar);
deep = planted with root collar 5 cm below soil line.

Seedling Growth

Both the shovel and new tool planted PSB 323M seedlings were taller than the PSB 323J and the PSB 313M seedlings when measured in September 1989, at the end of the first full growing season (Table 5). Total heights were consistent with the differences in seedling height at the time of planting in August 1988. There was, however, a difference in 1989 leader increment. The PSB 323M seedlings planted with the new tool had less leader growth than the shovel planted PSB 323M seedlings. Leader increment for the PSB 323J seedlings planted with the new tool did not exhibit such a reduction. Despite initial total height being less, leader increment for the PSB 323J seedlings planted with the new tool did not differ from the leader increment of the shovel planted PSB 323M seedlings. Seedlings diameters and volumes at the end of the 1989 growing season reflected initial seedling stature. The PSB 323M seedlings were larger than the PSB 323J and the PSB 313M seedlings for these parameters.

Table 5. Survival and growth parameters at the end of the first full growing season for PSB 323 and PSB 313 stock planted in various mound types, with a shovel or the new planting tool to different planting depths at the Beaver Road Site (3 September 1989).

Treatment				Condition				
Stock[1] type	Mound[2] size	Plant[3] tool	Depth[4] plant	Survival %	Total height cm	Height incr. cm	Stem diam. mm	Stem volume cm
323M	12	old	ctrl	100	49.4a[5]	7.9a	8.1a	8.9a
323M	20	old	ctrl	99	49.2a	7.5a	8.0a	8.6a
323M	12	new	ctrl	100	46.5a	5.9bcd	8.0a	8.6a
323M	20	new	ctrl	100	47.8	6.6bcd	7.9a	8.5a
323J	12	new	ctrl	96	30.2cd	7.8a	6.4bc	3.4c
323J	20	new	ctrl	100	26.7c	7.3a	6.2	3.1c
313M	12	new	ctrl	93	29.8cd	4.1e	5.9c	3.0c
313M	20	new	ctrl	93	29.3	5.3de	6.9b	4.9b
313M	12	new	deep	97	31.4c	6.8ab	6.3bc	3.3c
313M	20	new	deep	100	37.0b	5.4de	6.1c	3.1c

[1]**Stock type:** PSB 323M (March sown); PSB 323J (June sown); PSB 313M (March sown).
[2]**Mound size:** 12 or 20 cm of mineral soil capping over inverted humus.
[3]**Planting tool:** old = shovel; new = new tool.
[4]**Planting depth:** ctrl = control (planted to root collar);
deep = deep (planted with root collar 5 cm below soil line).
[5]Values in a column followed by the same letter are not significantly different ($p = 0.05$).

The weight of new roots produced by the PSB 323M seedlings was appreciably greater than the weight of new roots produced by the PSB 323J and the PSB 313M seedlings (Table 6). This difference was consistent with the differences in weight at the time of planting.

Table 6. Stem and root parameters for seedlings excavated at the end of the first full growing season in October 1989, at the Beaver Road Site.

Stock[1] type	Mound[2] size	Plant[3] tool	Depth[4] plant	Top weight g	Stem weight g	Needle weight g	Root weight g	New root weight g
323M	20	old	ctrl	17.2a[5]	8.8a	8.4a	5.4a	0.27a
323J	20	new	ctrl	13.1b	7.8b	5.3b	4.0b	0.18ab
313M	20	new	ctrl	8.4c	4.4c	3.9c	2.8c	0.11b
313M	20	new	deep	9.1c	5.7b	3.4c	2.1c	0.12b

[1]Stock type: PSB 323M (March sown); PSB 323J (June sown); PSB 313M (March sown).
[2]Mound size: 12 or 20 cm of mineral soil capping over inverted humus.
[3]Planting tool: old = shovel; new = new tool.
[4]Planting depth: ctrl = control (planted to root collar); deep = deep (planted with root collar 5 cm below soil line).
[5]Values in a column followed by the same letter are not significantly different (p = 0.05).

Vegetation Ingrowth

The height of vegetation on mounds was considerably less than the height of vegetation in the untreated areas between mounds (Table 7). Capping depth made no difference in the height of vegetation on mounds. The 20 cm mineral soil cappings on mounds controlled the cover of competing vegetation better than the 12 cm cappings.

Table 7. Height and cover of competing vegetation during the second growing season (July 1989) since construction of inverted humus mounds, at the Beaver Road Site.

Treatment	Vegetation	
	Height cm	Cover %
Untreated	51a[1]	78a
12 cm cap	27b	35b
20 cm cap	26b	24c

[1]Values in a column followed by the same letter do not differ significantly (p = 0.05).

Planting Tool

The double layer of humus within inverted humus mounds and the depth of mounds makes them relatively difficult to plant using a planting shovel. Roots and debris from the double humus layer tends to rebound into the shovel hole thereby obstructing insertion of seedlings to full depth. The prototype planting tool (Fig. 4) overcame the difficulties inherent in planting mineral capped inverted humus mounds.

Fig. 4 Planting tool developed for long-rooted seedlings. Foot rests facilitate forcing the planter into the ground. A seedling is being loaded into the magazine.

The prototype planting tool consists of a nose cone which, when thrust into the ground, makes a passage for a sleeve. The seedling is inserted into the sleeve for planting. The nose cone is co-axial with the sleeve and slightly smaller in diameter. A raised ring on the cone provides clearance as well as acting as a dirt scraper. A foot rest is provided to assist insertion of the planter into the mound. After the nose cone and sleeve have been pressed into the mound, the nose cone is raised vertically through the tube. The seedling, which is poised in a magazine contiguous with the sleeve, is then dropped into the sleeve and falls to the bottom of the planting hole. An inverted skirt, which is fixed to the nose cone, serves as a gate to keep the seedling in the magazine until the skirt and nose cone assembly is lifted clear of the opening through which the seedlings enters the sleeve. The sleeve is of sufficient diameter to allow it to be lifted upward and out of the soil without pulling the seedling out of the ground. When the sleeve is clear of the seedling top, the seedling is firmed up with the nose cone and the planter's boot.

Loentech Engineering is negotiating with International Forestech Systems Ltd (IFS) of Richmond B.C. concerning further development of the new planting tool. Loentech is assisting IFS in obtaining a licencing agreement with Canadian Patents.

The prototype planting tool was found to work satisfactorily for planting the long-rooted seedlings used in this trial. The following points were noted during use of the tool for planting.

1. The long taper and solid end to the tube made plunging the tool into mounds quite easy.

2. Difficulty was experienced on another site when planting into hard, untreated ground. Use of long-rooted (23 cm) seedlings and a tool to plant them is probably unnecessary on untreated ground with shallow LFH layers.

3. Normal sized 2+0 PSB 323J seedlings could be loaded into the tool, slid down the tube and released satisfactorily.

4. The March sown 2+0 PSB 323M seedlings were larger than normal; some of these seedlings slid down the tube with difficulty. While this problem could be overcome by using a larger tube for the tool, increase in tube diameter should be approached with caution because the tube would then be harder to drive into the ground.

5. Seedlings could easily be firmed in the mound by driving the tool into the ground in front of the seedling at an angle, followed by straightening the tube toward the seedling to compact soil against its root.

6. The planting tool was especially useful when mounds were dry because dry soil falls into the hole made by the planting shovel making shovel planting difficult. No difficulty was experienced due to dry soil filling the planting hole when the new tool was used.

7. The following modifications would make the tool even more effective:
   a. the tool should be lighter;
   b. there should be a positive centering and locking mechanism to return the tool to the closed position prior to loading a new seedling;
   c. the dibble end could be longer to facilitate penetration of the soil.

Discussion

The satisfactory performance of the new planting tool suggests that it should be developed as a production tool for planting long-rooted seedlings. Such a tool could also be more efficient for planting standard seedlings (eg. PSB 313) in untreated sites than a planting shovel. The planting hole formed by a shovel may become partly obstructed by roots and debris as the shovel is moved to make way for the seedling. Insertion of the seedlings into the shovel hole is thereby hampered. Insertion of the seedling into the sleeve of the new planter obviates such difficulties. Although the new tool cannot readily be used for screefing, experience has shown that screefing is commonly unnecessary when seedlings are well and deeply enough planted.

Results to date show that the PSB 323 seedlings grew larger than the PSB 313 seedlings during the first growing season. The PSB 323M (March sown) seedlings also had more new roots than the PSB 313 seedlings. In both cases these results reflect the large initial size of the PSB 323 seedlings. Whether the lower height increment of the PSB 323M (March sown) seedlings planted with the new tool compared with the shovel planted seedlings reflects a real performance difference cannot be judged definitively from first year results in a single trial.

This trial should be monitored for several more years to determine whether the differences apparent after the first full growing season will be maintained. Further trials to compare the alternatives examined in this trial should be initiated because this trial is limited to one ecosystem. The new planting tool, however, provided equally satisfactory survival. The PSB 323 seedlings had superior performance to the PSB 313 seedlings.

Conclusions

The prototype planting tool was very satisfactory. It could readily be plunged into deep mounds and seedlings were easily released, even into dry soil. Despite the dryness of the mounds at the time of planting, all seedlings survived. It was not possible to ascertain from this experiment whether the superior performance of the long-rooted seedlings resulted from their larger initial size or whether their long roots were beneficial.

Literature Cited

Draper, D and L.J. Herring. 1986. Working Plan: Site stress x stock type stress resistance interactions on Sub-Boreal Spruce NSR Backlog Sites. B.C. Ministry of Forests and Lands, Research Branch E.P. 971.03. 17p.

Hedin, I.B. 1989. Inverted Humus Mounds: Follow-up Field Assessments. FRDA Report 072, 12p.

Holland, S. 1976. Landforms of British Columbia. A physiographic outline. B.C. Dept. Mines and Petrol. Res., Bull.48, 138p.

Hortie, H.J., A.J. Green and T.M. Lord. 1970. Soils of the Upper Part of the Fraser Valley in the Rocky Mountain Trench of British Columbia. Can. Dept. Agr., Rep. No. 10 of the B.C. Soil Survey. 55p.

Appendix

Condition of seedlings on 17 September 1988 at the Beaver Road Site.

Plot	Stock	Affected Seedlings					
		Lower Foliage					
		Green/drooping	Brown	Red	Dead bud	Moose tread	Hare clip
A1	LM	4217,4224 -	4212,4216,4220	- - -	-	4203	-
A2	SM	- - -	- - -	- - -	-	-	-
A3	LJ	- - -	- - -	- - -	-	-	-
A3	LM	- - -	- - -	4801,4802,4805,	-	-	-
		- - -	- - -	4808,4811,4818	-	-	-
A4	SM	4291,4296 -	4277,4278,4279,	- - -	-	4285	-
		- - -	4280,4281,4282,	- - -	-	-	-
		- - -	4283,4284,4286,	- - -	-	-	-
		- - -	4290,4295 -	- - -	-	-	-
A5	SM	- - -	- - -	- - -	-	-	-
A6	LM	- - -	- - -	- - -	-	-	-
A7	SM	4350,4361 -	- - -	4349,4362,4363	-	-	-
A8	LJ	- - -	- - -	- - -	-	-	4378
		- - -	- - -	- - -	-	-	4383
A8	LM	- - -	- - -	- - -	-	-	-
B1	SM	- - -	4408 - -	- - -	-	-	-
B2	LJ	- - -	- - -	- - -	-	-	-
B2	LM	4823,4838 -	- - -	4825,4826 -	-	4832	-
B3	LM	4441,4448,4450,	- - -	4449,4451,4452,	-	-	-
		4460 - -	- - -	4454 - -	-	-	-
B4	SM	4469,4480,4486,	4485 - -	4472,4482,4483	-	-	-
		4487 - -	- - -	- - -	-	-	-
B5	LJ	4501 - -	- - -	- - -	-	-	-
B5	LM	4844,4852,4860	- - -	4841,4855 -	-	-	-
B6	LM	- - -	- - -	- - -	-	-	-
B7	LM	4548 - -	- - -	- - -	-	-	-
B8	LM	580 - -	- - -	- - -	-	-	-
C1	SM	4590 - -	4588,4591,4596,	- - -	-	-	-
		- - -	4602 - -	- - -	-	-	-
C2	LJ	- - -	- - -	- - -	-	-	-
C2	LM	- - -	- - -	- - -	4878	-	-
C3	LJ	- - -	- - -	- - -	-	-	-
C3	LM	4862 - -	4866 - -	4867,4873,4877	-	-	-
C4	SM	4679 - -	- - -	- - -	-	-	-
C5	LM	- - -	- - -	- - -	-	-	-
C6	SM	- - -	- - -	4724 - -	-	-	-
C7	SM	4744 - -	4742,4743,4745,	4737 - -	-	-	-
		- - -	4747,4752 -	- - -	-	-	-
C8	LM	- - -	4755,4760,4774	- - -	-	-	-

LM = March sown PSB 323; LJ = June sown PSB 323; SM = March sown PSB 313.'